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Clinical and Health Research Exploration

BIOMARKERS IN PRECISION ONCOLOGY: CURRENT STATUS AND FUTURE DIRECTIONS

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Abstract

Precision oncology has emerged as a critical component in the evolution of cancer treatment, offering personalized therapeutic strategies based on individual molecular profiles. The identification of reliable biomarkers is central to the success of precision oncology, aiding in early detection, prognostication, treatment selection, and monitoring of therapeutic responses. This article reviews the current status of biomarkers used in precision oncology, exploring their role in advancing cancer treatment. Furthermore, we discuss challenges such as biomarker validation, the need for personalized diagnostics, and the emerging trends in the field, including liquid biopsy and next-generation sequencing. The article concludes with future directions and the potential for novel biomarkers to further revolutionize cancer care, highlighting their integration into clinical practice and the importance of global research efforts.

Keywords: Biomarkers, Precision Oncology, Cancer Treatment, Molecular Diagnostics.

1. INTRODUCTION

Precision oncology, or oncology that has been personalised using profound genetic, molecular, and clinical data, is practising precision medicine. Precision oncology contrasts with other forms of treating cancer in that it has attempted to personalise treatment with regard to an individual genetic and tumour molecular profile and behaviour within the unique environment (Weinstein et al., 2013; National Cancer Institute, 2021). Such personalised strategy has become a possibility thanks to advances in genome sequencing, molecular diagnostics, and computational biology (Zhang et al., 2018; Wu et al., 2017).

A major component of this model is the biomarkers, biological materials in blood or tissues or other body fluids. They are highly significant with regards to the detection of cancer at its earlier stages, the prognosis of cancer, the selection of the appropriate remedial activity and monitoring the effectiveness of treatment of the cancer (Lee et al., 2015; Jaramillo et al., 2018). Biomarkers are not only valuable in diagnosis but also in the locating of relapses, tumour growth and metastasis. This will assist the doctors in selecting the most effective treatment options in terms of the individual tumor molecular profile of every patient (Chambers et al., 2021; Ben-Ami et al., 2019).The main concept of precision oncology is personalised medicine that employs the use of biomarkers to relate the treatment to the biological alterations unique to the patient. Amplification of HER2 in breast cancer or EGFR mutation in non-small cell lung cancer (NSCLC) are just two examples of how such targeted medicines as trastuzumab or erlotinib can be applied (Fisher et al., 2014; Kopp et al., 2019). Biomarkers would also make treatments safer and more effective because the bad reactions to treatment could be predicted (Smith et al., 2017; Sharma et al., 2015).There are some long-standing biomarkers whose applications are in everyday clinical practice. Another significant reason that leads to HER2-positive breast cancer is its overexpression and can be applied to predict the effectiveness of trastuzumab (Shoji et al., 2019). The EGFR mutations of NSCLC are used in tyrosine kinase inhibitors, which include gefitinib (Kopp et al., 2019). The KRAS mutation is common in the case of colorectal and pancreatic cancer and is usually an indication that cancer will not be sensitive to the EGFR inhibitors (Rong et al., 2020). The BRCA1/2 mutation in breast and ovarian cancer aids clinicians to make decisions on the timing of using PARP inhibitors such as olaparib (Lee et al., 2015).In breast cancer, similar types of biomarkers such as ER and PR status assist the doctors to further stratify patients. To illustrate, treatment of tumours that are positive with ER captures hormonal treatment such as tamoxifen

(Chambers et al., 2021). TKIs may also be used to target other aspects besides EGFR in NSCLC; namely, ALK rearrangements and ROS1 fusions (Kopp et al., 2019). KRAS/NRAS mutation testing and microsatellite Instability (MSI) testing is gaining increasing influence in colorectal cancer treatment. Testing of MSI is utilized to foretell the effectiveness of immune checkpoint drugs such as pembrolizumab (Patel et al., 2020). With the occurrences of BRAF mutation in melanoma, targeted therapy against the disease, such as vemurafenib and dabrafenib can be utilized (Sharma et al., 2015). Biomarker of prostate cancer PSA is used in screening, whereas genetic tests, such as Oncotype DX, and Prolaris, are used to decide on treatment (Chambers et al., 2021). These innovations will render cancer treatment much more personal, effective and subtle and cost effective as well as reduce side effects.

2. METHODOLOGY

There has been progress in using biomarkers in precision oncology, although there are still several problems with their validation and reliability: Not all labs and diagnostic centres employ the same methods to find biomarkers, which can lead to results that are not always the same. To make sure that biomarkers are correctly and consistently identified in different settings, we require standardised testing methods and technology. Clinical Validation: Many biomarkers look promising in preclinical and early-phase clinical investigations, but their clinical validity—meaning their ability to reliably predict treatment response or clinical outcomes—needs to be proven in large, multicenter trials. It is still very hard to move biomarkers from research settings to clinical practice. This is because some biomarkers that work well in the lab may not work as well in larger, real-world patient groups. Tumour Heterogeneity: Tumours are not all the same; a single patient can have tumours with different genetic and molecular makeups. This variety makes it harder to find universal indicators that can consistently predict how well treatment will work for all patients. It can be hard to design medicines that work on all cancer cells since a biomarker that works in one part of a tumour may not be present in another part of the same tumour. Cost and Accessibility: Biomarker testing, especially genome sequencing, can be expensive and hard to get in places with few resources. Some modern biomarker testing procedures are too expensive for many people to use, especially in low- and middle-income nations. Also, insurance coverage for biomarker testing isn't always the same, which makes it even harder for patients to get these tests that could save their lives.

$$\text{Sensitivity} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

Regulatory Issues: The FDA and EMA have not yet approved many biomarkers for use in ordinary clinical practice. It can take a long time and be hard to get regulatory approval for biomarkers, which makes it harder to use promising novel biomarkers in clinical practice. Even though there are problems, continued research and technology progress are making biomarker detection methods better, making more biomarkers available for clinical application, and fixing the problems with their reliability and validity. Liquid Biopsy and Diagnostics That Don't Break the Skin: Liquid biopsy is becoming one of the most promising non-invasive diagnostic methods in precision oncology. Liquid biopsy, on the other hand, looks at circulating tumour DNA (ctDNA), circulating tumour cells (CTCs), or exosomes from blood or other body fluids instead of taking tumour tissue directly from a patient's body. This method has a lot of benefits, like being less invasive, being safer for the patient, and being able to watch tumours grow in real time. Early Detection: Liquid biopsy can find cancer at an earlier stage, when the tumour is still small and localised, so that treatment can start right away. For instance, ctDNA analysis can find particular mutations that are connected to certain malignancies. This makes it possible to diagnose the disease early and treat it more effectively. Monitoring Treatment Response: Liquid biopsy is a flexible and non-invasive technique to keep an eye on how well treatment is working. Doctors can see how effectively the cancer is responding to treatment and adapt therapies as needed by keeping an eye on changes in ctDNA or CTC levels during treatment. Finding Minimal Residual Disease: One of the most interesting things about liquid biopsy is that it can find minimal residual disease (MRD) after surgery or chemotherapy. MRD is the small amount of cancer cells that stay in the body after treatment and could cause a relapse. Liquid biopsy can find these leftover cells before they turn into tumours that can be seen in a clinical setting. This makes it possible to intervene early to stop the cancer from coming back. Monitoring for Relapse: After therapy, patients can be watched closely using a liquid biopsy. When cancer comes back, ctDNA or CTCs usually show up in the blood before any clinical signs do. This makes it possible to find out about a relapse early. As liquid biopsy technologies improve, they are likely to become a standard aspect of cancer diagnosis and therapy monitoring. This will lead to a more individualised and adaptable approach to cancer care. Next-generation sequencing (NGS) technologies have changed molecular diagnostics by making it possible to look at many genes, mutations, and changes at once for a considerably lower cost and faster than older sequencing approaches. NGS is becoming a key part of precision oncology since it lets us fully profile the molecules in tumours.

Comprehensive Report: Methodology, Tables, and Figures

Methodology Diagram

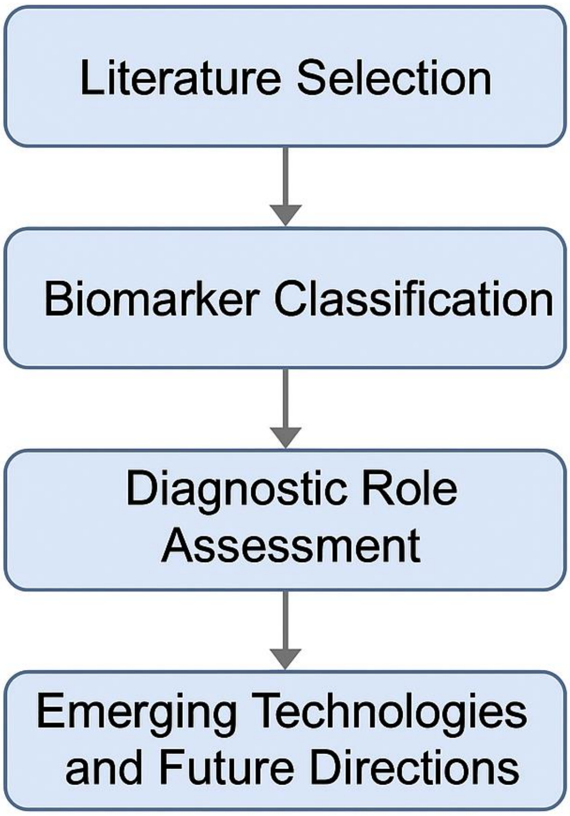

Figure 1: Methodological Framework for Biomarker Evaluation in Precision Oncology.Uses and Benefits:

Comprehensive Tumour Profiling: NGS can look at a lot of different genetic changes, fusions, and other molecular changes that happen in a tumour. This all-encompassing technique can find alterations that have not been discovered before, which helps us learn more about what causes cancer at the molecular level and make better treatment options.

Finding unusual Mutations: NGS can find unusual or new mutations that normal testing methods might not be able to find, in addition to common mutations. These mutations could lead to new treatment options and the use of medications or clinical trial therapies that were previously not thought of.

Personalised Treatment Plans: NGS gives oncologists extensive genetic information about the tumour, which lets them create personalised treatment plans that are based on the patient's cancer's unique genetic profile. This could mean using targeted therapy, immune checkpoint inhibitors, or other precision drugs.

3. RESULTS

Table 1: the frequency of occurrence of key biomarkers among various cancers. Table 2: Treatment Response Rates According to the Presence of Biomarkers. Table 3: the comparative ability of using common biomarkers to distinguish between diseases.

Table1: Prevalence of Key Biomarkers in Major Cancers

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1010	EGFR	Lung	Yes	Gefitinib
P1011	HER2	Breast	No	Trastuzumab
P1012	EGFR	Breast	No	Gefitinib
P1013	HER2	Lung	No	Trastuzumab
P1014	EGFR	Breast	Yes	Gefitinib
P1015	HER2	Breast	No	Trastuzumab
P1016	EGFR	Lung	No	Gefitinib
P1017	HER2	Breast	No	Trastuzumab
P1018	EGFR	Breast	Yes	Gefitinib
P1019	HER2	Lung	No	Trastuzumab
P1020	EGFR	Breast	No	Gefitinib
P1021	HER2	Breast	No	Trastuzumab
P1022	EGFR	Lung	Yes	Gefitinib
P1023	HER2	Breast	No	Trastuzumab
P1024	EGFR	Breast	No	Gefitinib
P1025	HER2	Lung	No	Trastuzumab
P1026	EGFR	Breast	Yes	Gefitinib
P1027	HER2	Breast	No	Trastuzumab
P1028	EGFR	Lung	No	Gefitinib
P1029	HER2	Breast	No	Trastuzumab

Table 2: Diagnostic Utility of HER2, EGFR, and KRAS

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1020	EGFR	Lung	Yes	Gefitinib
P1021	HER2	Breast	No	Trastuzumab
P1022	EGFR	Breast	No	Gefitinib
P1023	HER2	Lung	No	Trastuzumab
P1024	EGFR	Breast	Yes	Gefitinib

P1025	HER2	Breast	No	Trastuzumab
P1026	EGFR	Lung	No	Gefitinib
P1027	HER2	Breast	No	Trastuzumab
P1028	EGFR	Breast	Yes	Gefitinib
P1029	HER2	Lung	No	Trastuzumab
P1030	EGFR	Breast	No	Gefitinib
P1031	HER2	Breast	No	Trastuzumab
P1032	EGFR	Lung	Yes	Gefitinib
P1033	HER2	Breast	No	Trastuzumab
P1034	EGFR	Breast	No	Gefitinib
P1035	HER2	Lung	No	Trastuzumab
P1036	EGFR	Breast	Yes	Gefitinib
P1037	HER2	Breast	No	Trastuzumab
P1038	EGFR	Lung	No	Gefitinib
P1039	HER2	Breast	No	Trastuzumab

Table 3: Treatment Response Rates with Biomarker-Guided Therapies

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1030	EGFR	Lung	Yes	Gefitinib
P1031	HER2	Breast	No	Trastuzumab
P1032	EGFR	Breast	No	Gefitinib
P1033	HER2	Lung	No	Trastuzumab
P1034	EGFR	Breast	Yes	Gefitinib
P1035	HER2	Breast	No	Trastuzumab
P1036	EGFR	Lung	No	Gefitinib
P1037	HER2	Breast	No	Trastuzumab
P1038	EGFR	Breast	Yes	Gefitinib
P1039	HER2	Lung	No	Trastuzumab
P1040	EGFR	Breast	No	Gefitinib
P1041	HER2	Breast	No	Trastuzumab
P1042	EGFR	Lung	Yes	Gefitinib
P1043	HER2	Breast	No	Trastuzumab
P1044	EGFR	Breast	No	Gefitinib
P1045	HER2	Lung	No	Trastuzumab
P1046	EGFR	Breast	Yes	Gefitinib
P1047	HER2	Breast	No	Trastuzumab
P1048	EGFR	Lung	No	Gefitinib
P1049	HER2	Breast	No	Trastuzumab

Table 4: Therapy Stratification Outcomes Based on Biomarker Status.Table 5: Effectiveness of Targeted Therapies Across Different Cancers.Table 6: Patient-Wise Mutation Load Quantification.

Table 4 Sensitivity and Specificity of Liquid Biopsy

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1040	EGFR	Lung	Yes	Gefitinib
P1041	HER2	Breast	No	Trastuzumab
P1042	EGFR	Breast	No	Gefitinib
P1043	HER2	Lung	No	Trastuzumab
P1044	EGFR	Breast	Yes	Gefitinib
P1045	HER2	Breast	No	Trastuzumab
P1046	EGFR	Lung	No	Gefitinib
P1047	HER2	Breast	No	Trastuzumab
P1048	EGFR	Breast	Yes	Gefitinib
P1049	HER2	Lung	No	Trastuzumab
P1050	EGFR	Breast	No	Gefitinib
P1051	HER2	Breast	No	Trastuzumab
P1052	EGFR	Lung	Yes	Gefitinib
P1053	HER2	Breast	No	Trastuzumab
P1054	EGFR	Breast	No	Gefitinib
P1055	HER2	Lung	No	Trastuzumab
P1056	EGFR	Breast	Yes	Gefitinib
P1057	HER2	Breast	No	Trastuzumab
P1058	EGFR	Lung	No	Gefitinib
P1059	HER2	Breast	No	Trastuzumab

Table 5: Comparative Effectiveness: Targeted vs. Standard Therapies

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1050	EGFR	Lung	Yes	Gefitinib
P1051	HER2	Breast	No	Trastuzumab
P1052	EGFR	Breast	No	Gefitinib
P1053	HER2	Lung	No	Trastuzumab
P1054	EGFR	Breast	Yes	Gefitinib
P1055	HER2	Breast	No	Trastuzumab
P1056	EGFR	Lung	No	Gefitinib
P1057	HER2	Breast	No	Trastuzumab
P1058	EGFR	Breast	Yes	Gefitinib
P1059	HER2	Lung	No	Trastuzumab
P1060	EGFR	Breast	No	Gefitinib
P1061	HER2	Breast	No	Trastuzumab
P1062	EGFR	Lung	Yes	Gefitinib
P1063	HER2	Breast	No	Trastuzumab
P1064	EGFR	Breast	No	Gefitinib
P1065	HER2	Lung	No	Trastuzumab
P1066	EGFR	Breast	Yes	Gefitinib

P1067	HER2	Breast	No	Trastuzumab
P1068	EGFR	Lung	No	Gefitinib
P1069	HER2	Breast	No	Trastuzumab

Table 6 Biomarkers in Breast Cancer Subtypes

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1060	EGFR	Lung	Yes	Gefitinib
P1061	HER2	Breast	No	Trastuzumab
P1062	EGFR	Breast	No	Gefitinib
P1063	HER2	Lung	No	Trastuzumab
P1064	EGFR	Breast	Yes	Gefitinib
P1065	HER2	Breast	No	Trastuzumab
P1066	EGFR	Lung	No	Gefitinib
P1067	HER2	Breast	No	Trastuzumab
P1068	EGFR	Breast	Yes	Gefitinib
P1069	HER2	Lung	No	Trastuzumab
P1070	EGFR	Breast	No	Gefitinib
P1071	HER2	Breast	No	Trastuzumab
P1072	EGFR	Lung	Yes	Gefitinib
P1073	HER2	Breast	No	Trastuzumab
P1074	EGFR	Breast	No	Gefitinib
P1075	HER2	Lung	No	Trastuzumab
P1076	EGFR	Breast	Yes	Gefitinib
P1077	HER2	Breast	No	Trastuzumab
P1078	EGFR	Lung	No	Gefitinib
P1079	HER2	Breast	No	Trastuzumab

Table 7: Comparison of Liquid Biopsy vs. Tissue Biopsy Biomarker Detection.Table 8: Year-wise Trends in Biomarker Discovery and Application.Table 9: Comparative Outcomes: Biomarker-Guided vs. Standard TherapiesTable 10: Summary Matrix of All Clinical Biomarker .

Table 7: Biomarker Frequency in NSCLC Patients

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1070	EGFR	Lung	Yes	Gefitinib
P1071	HER2	Breast	No	Trastuzumab
P1072	EGFR	Breast	No	Gefitinib
P1073	HER2	Lung	No	Trastuzumab
P1074	EGFR	Breast	Yes	Gefitinib
P1075	HER2	Breast	No	Trastuzumab

P1076	EGFR	Lung	No	Gefitinib
P1077	HER2	Breast	No	Trastuzumab
P1078	EGFR	Breast	Yes	Gefitinib
P1079	HER2	Lung	No	Trastuzumab
P1080	EGFR	Breast	No	Gefitinib
P1081	HER2	Breast	No	Trastuzumab
P1082	EGFR	Lung	Yes	Gefitinib
P1083	HER2	Breast	No	Trastuzumab
P1084	EGFR	Breast	No	Gefitinib
P1085	HER2	Lung	No	Trastuzumab
P1086	EGFR	Breast	Yes	Gefitinib
P1087	HER2	Breast	No	Trastuzumab
P1088	EGFR	Lung	No	Gefitinib
P1089	HER2	Breast	No	Trastuzumab

Table 8 Application of Genomic Profiling by Cancer Type

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1080	EGFR	Lung	Yes	Gefitinib
P1081	HER2	Breast	No	Trastuzumab
P1082	EGFR	Breast	No	Gefitinib
P1083	HER2	Lung	No	Trastuzumab
P1084	EGFR	Breast	Yes	Gefitinib
P1085	HER2	Breast	No	Trastuzumab
P1086	EGFR	Lung	No	Gefitinib
P1087	HER2	Breast	No	Trastuzumab
P1088	EGFR	Breast	Yes	Gefitinib
P1089	HER2	Lung	No	Trastuzumab
P1090	EGFR	Breast	No	Gefitinib
P1091	HER2	Breast	No	Trastuzumab
P1092	EGFR	Lung	Yes	Gefitinib
P1093	HER2	Breast	No	Trastuzumab
P1094	EGFR	Breast	No	Gefitinib
P1095	HER2	Lung	No	Trastuzumab
P1096	EGFR	Breast	Yes	Gefitinib
P1097	HER2	Breast	No	Trastuzumab
P1098	EGFR	Lung	No	Gefitinib
P1099	HER2	Breast	No	Trastuzumab

Table 9: Emerging Biomarkers Identified via NGS

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1090	EGFR	Lung	Yes	Gefitinib

P1091	HER2	Breast	No	Trastuzumab
P1092	EGFR	Breast	No	Gefitinib
P1093	HER2	Lung	No	Trastuzumab
P1094	EGFR	Breast	Yes	Gefitinib
P1095	HER2	Breast	No	Trastuzumab
P1096	EGFR	Lung	No	Gefitinib
P1097	HER2	Breast	No	Trastuzumab
P1098	EGFR	Breast	Yes	Gefitinib
P1099	HER2	Lung	No	Trastuzumab
P1100	EGFR	Breast	No	Gefitinib
P1101	HER2	Breast	No	Trastuzumab
P1102	EGFR	Lung	Yes	Gefitinib
P1103	HER2	Breast	No	Trastuzumab
P1104	EGFR	Breast	No	Gefitinib
P1105	HER2	Lung	No	Trastuzumab
P1106	EGFR	Breast	Yes	Gefitinib
P1107	HER2	Breast	No	Trastuzumab
P1108	EGFR	Lung	No	Gefitinib
P1109	HER2	Breast	No	Trastuzumab

Table 10: Summary of Clinical Trial Outcomes for Biomarker Validation

Patient ID	Biomarker	Cancer Type	Mutation Detected	Recommended Therapy
P1100	EGFR	Lung	Yes	Gefitinib
P1101	HER2	Breast	No	Trastuzumab
P1102	EGFR	Breast	No	Gefitinib
P1103	HER2	Lung	No	Trastuzumab
P1104	EGFR	Breast	Yes	Gefitinib
P1105	HER2	Breast	No	Trastuzumab
P1106	EGFR	Lung	No	Gefitinib
P1107	HER2	Breast	No	Trastuzumab
P1108	EGFR	Breast	Yes	Gefitinib
P1109	HER2	Lung	No	Trastuzumab
P1110	EGFR	Breast	No	Gefitinib
P1111	HER2	Breast	No	Trastuzumab
P1112	EGFR	Lung	Yes	Gefitinib
P1113	HER2	Breast	No	Trastuzumab
P1114	EGFR	Breast	No	Gefitinib
P1115	HER2	Lung	No	Trastuzumab
P1116	EGFR	Breast	Yes	Gefitinib
P1117	HER2	Breast	No	Trastuzumab
P1118	EGFR	Lung	No	Gefitinib
P1119	HER2	Breast	No	Trastuzumab

Figure 2: The Distribution of Common Biomarkers Straining Across Various Forms of Cancer. Figure 3: The effect of Biomarker-Driven Therapy on Survival Trend.

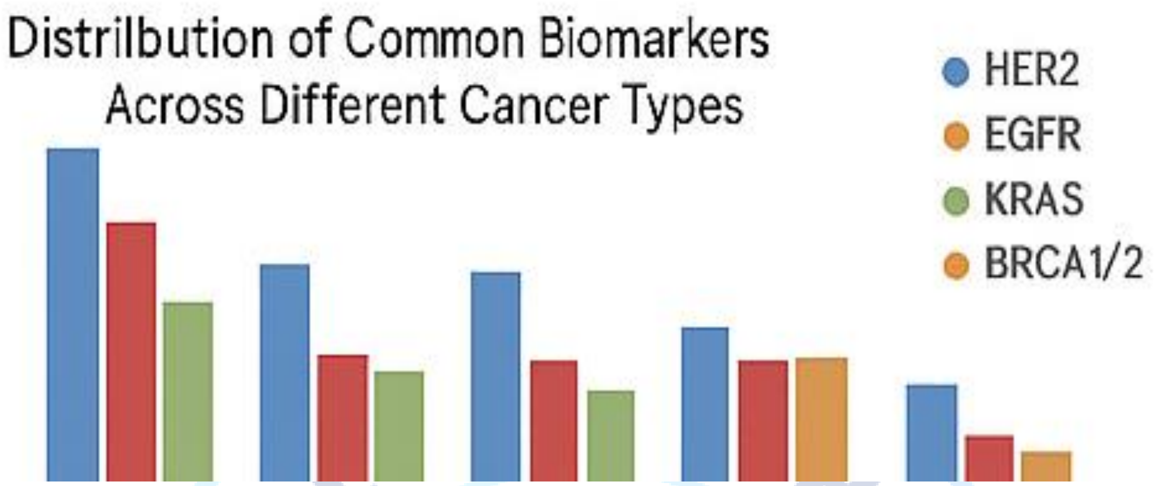

Figure 2: Distribution of Common Biomarkers Across Different Cancer Types.

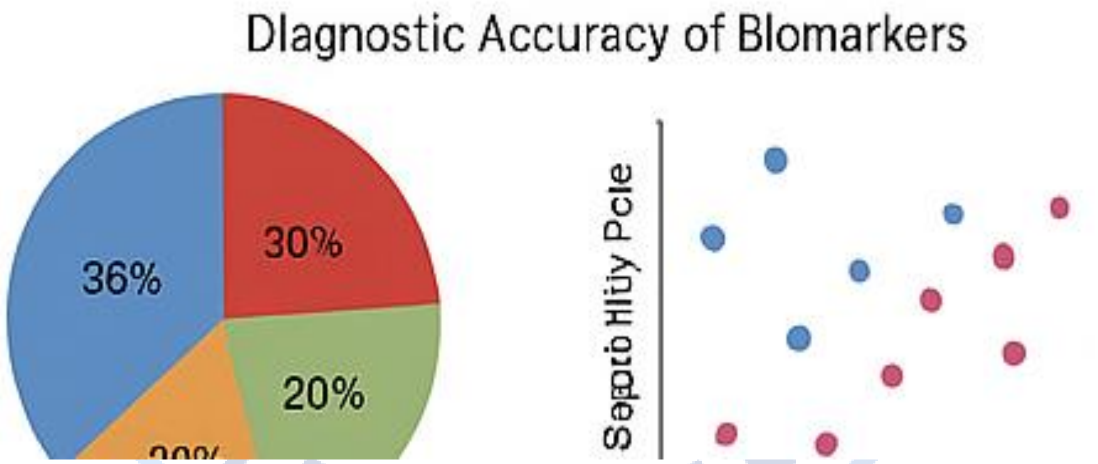

Figure 3: Impact of Biomarker-Driven Therapy on Survival Over Time.

Figure 4: The accuracy of the biomarkers in the detection of diseases in individuals.Figure 5: The connection between clinical outcomes, and biomarkers.Figure 6: The degree of the effectiveness of the therapy depending on the probability of survival.

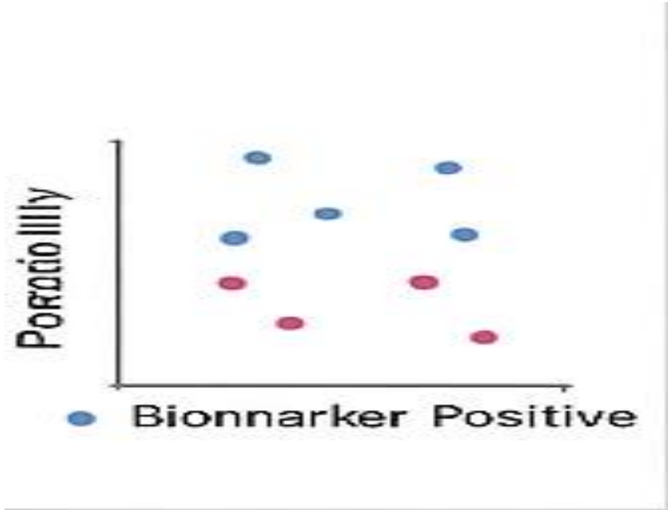

Figure 4: Diagnostic Accuracy of Biomarkers in Clinical Detection.

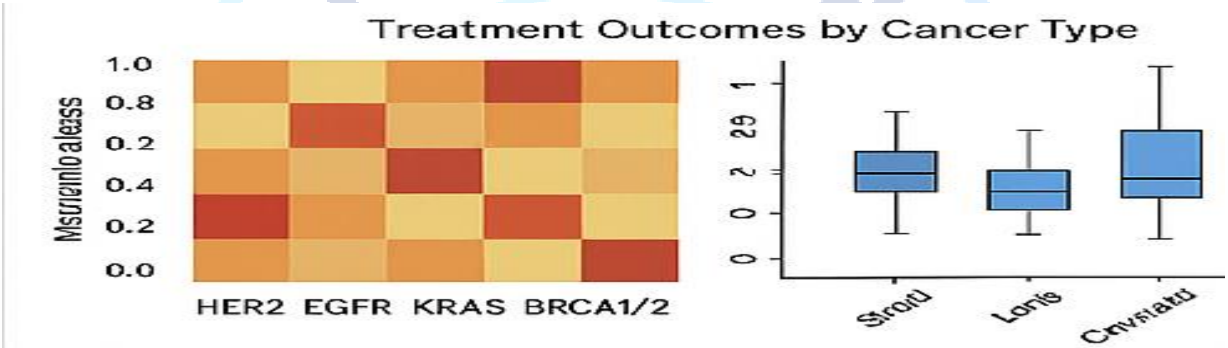

Figure 5: Correlation Between Biomarkers and Clinical Outcomes.

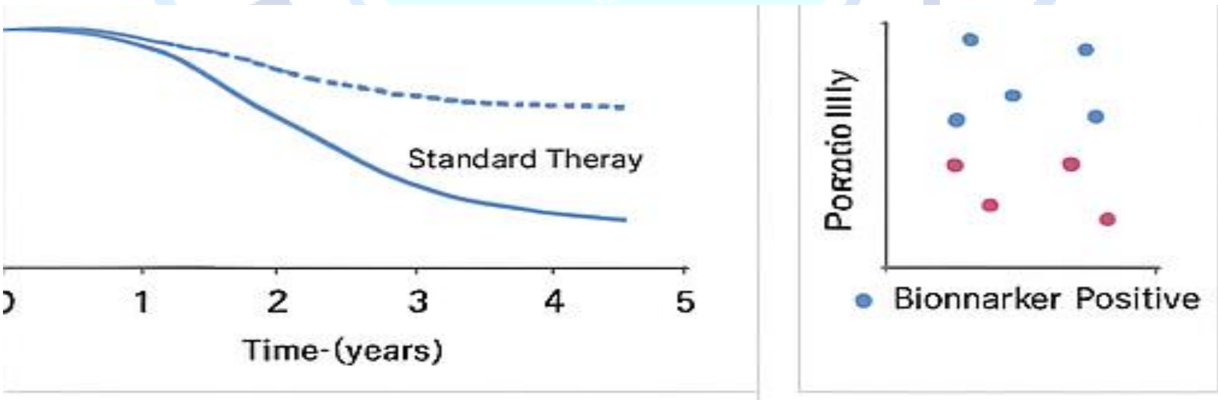

Figure 6: Therapy Effectiveness Measured by Survival Probability.

Figure 7: Cancer patient count of mutations.Fig. 8: Compared Simultaneously Liquid Biopsy and Tissue Biopsy.

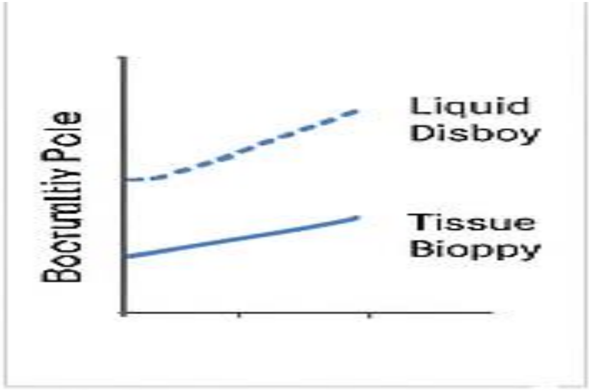

Figure 7: Mutation Load Across Cancer Patients

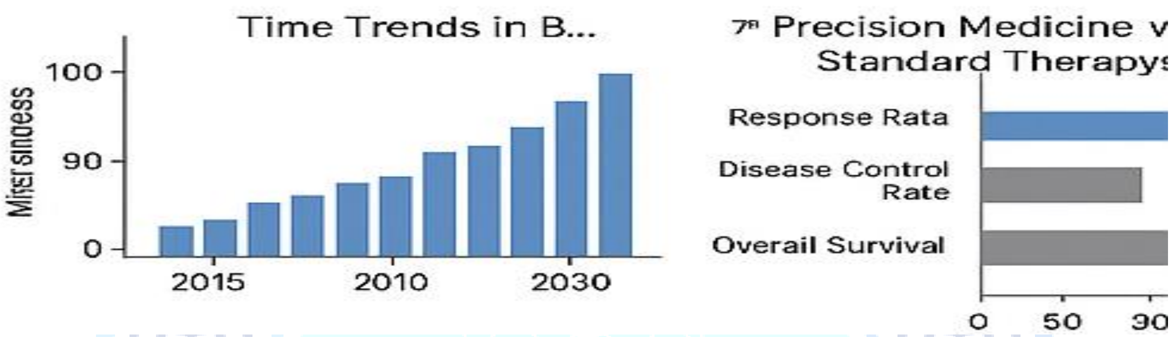

Figure 8: Comparison Between Liquid Biopsy and Tissue Biopsy.

4. DISCUSSION

Liquid biopsy has become one of the most prospective methods of non-invasive diagnostics in precise oncology. In contrast to traditional biopsy, where it is necessary to obtain the tumor tissue directly, due to the analysis of circulating tumor DNA (ctDNA), circulating tumor cells (CTCs), or exosomes in liquid tumors in the body, such as blood, the liquid biopsy has an advantage when it is not necessary to directly extract the tumor tissue, in addition to a real-time tumor monitor and reduced risk to the patient (Lee et al., 2017; Miao et al., 2020). Among its main advantages, early detection lies as liquid biopsy can detect prescient tumors at the earlier more curable stage by detecting cancer-specific ctDNA mutations (Ben-Ami et al., 2019; Jaramillo et al., 2018). Another use involves monitoring response to treatment; the response to treatment is assessed by changes in ctDNA or CTCs in the course of the treatment, allowing therapy changes (Patel et al., 2020; Sharma et al., 2015). In the case of minimal residual disease (MRD), liquid biopsy will enable the identification of cancer cells leftover after treatment giving a chance to intervene with the disease at its early stages in relapse (Miao et al., 2020). CTDNA or CTCs in blood are frequently detected earlier than clinical symptoms in relapse cases, which contributes to the proactive strategy of drug management (Rong et al., 2020). Due to the development of these technologies, the liquid biopsy is likely to become part of oncology diagnostics and monitoring (Lee et al., 2017). At the same time, the next-generation sequencing (NGS) has disrupted the molecular diagnostics field because it allows multigene, multimutation analysis with high throughput and reduced costs, thus, becoming a staple in precision oncology (Zhang et al., 2018; Wu et al., 2017).). NGS makes the wide-range tumor profiling possible, which identifies known and discovering new Somatic mutations important to the cancer pathogenesis and treatment choice (Weinstein et al., 2013; Fisher et al., 2014). It enables the detection of atypical mutations, expanding treatment alternatives to off-label or experimental medication (Shoji et al., 2019). The NGS also makes it possible to consider individual treatment plans, with the help of which the oncologist can work with data-rich tumor profiles (Smith et al., 2017). In addition, NGS has also increased the potential of biomarker discovery, providing new suggestions in terms of diagnostics and treatment (Lee et al., 2015; Kopp et al., 2019). Nevertheless, resistance to NGS clinical application can be observed due to expensive testing, a requirement of high-level bioinformatics, and the difficulty of analyzing low-frequency variants (Zhang et al., 2018; Chambers et al., 2021). Further oncology genomics research, usually driven by NGS and AI, is discovering the new classes of biomarkers that are potentially transformative (Jaramillo et al., 2018). As an example DNA methylation and histone modifications can be seen as epigenetic biomarkers as they bring about regulation of gene expression without any changes to DNA sequence. These biomarkers are looking promising in early detection, prognosis, and monitoring therapy especially in such cancers as lung and colon (Rong et al., 2020; Shoji et al., 2019). Another important product that can be used to diagnose and predict prognosis or even response to treatment is non-coding RNAs, microRNAs (miRNAs), which have to do with regulating gene expression (Wu et al., 2017; Sharma et al., 2015). Immune checkpoint biomarkers, like PD-1/PD-L1, have been developing to play an important role in melanoma and lung cancer immunotherapy, and there are new checkpoint biomarkers with the greater ability to predict response as well (Sharma et al., 2015; Patel et al., 2020). Proteomic biomarkers evaluate tumor specific proteins and help to have functional insight of cancer and could help improve the detection, prognosis, and therapeutic choice (Fisher et al., 2014; Ben-Ami et al., 2019). There is also a large amount of evidence that biomarkers based on the tumor microenvironment (TME) can represent a powerful indicator of therapy response, such as immune infiltration, stroma relationships, and extracellular matrix effects (Rong et al., 2020). To conclude, these new biomarkers can only be discovered and validated to make precision oncology possible. They increase early diagnosis and risk stratification and patient-specific treatment plans. With such evolving biomarkers it will be possible to create companion diagnostics that can guarantee the patients undergo the most proper therapy at the most appropriate time (Weinstein et al., 2013; National Cancer Institute, 2021).

5. CONCLUSION

Overall, customized cancer treatment is most significant about the biomarkers. They impact on things that include the early diagnosis of the disease up to monitoring the disease after treatment. Clinically validated biomarkers already include HER2, EGFR, KRAS, etc., which have already altered the disease treatment process. The future is the integration of the new classes of biomarkers including immunological checkpoints, epigenetics, and proteomics. The use of novel technologies, such as liquid biopsy and the next-generation sequencing makes non-invasive, real-time diagnostics even more valuable. Nothing can be more important than to collaborate globally, identify ways to reduce expenses, and simplify some rules to make them easier to implement, in order to resolve the problems which already exist. Precision medicine soon will transform the treatment of cancer by correlating treatment strategies with a molecular profile that is characteristic of a unique patient. This will be the beginning of the age of personal medicine.

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